Chapter 8 FUTURE URBANIZED AREA

The future urbanized area is one of the basic conditions for the Study. This Chapter explains the study on the estimation/selection of the future urbanized area from the viewpoint of city planning.

8.1 UNPLANNED URBANIZATION

The past trend of unplanned urbanization of Bangkok Metropolis and the Study Area is shown in Figs. 8.1 and 8.2 respectively. The urban area, expanding along national highway route 1 and the core fringe dating from 1960, included about one quarter (148 km^2) of the Study Area in 1980.

This rapid unplanned urbanization has caused the following problems.

- Heavy road traffic
- Floods
- Inadequate public utilities
- Pollution
- Crime
- Uncontrolled urbanization in agricultural areas.

8.2 EXISTING LAND USE

The population and urbanized area in the Study Area in 1980 were 1,160,000 persons and 148 km^2 respectively. (detailed descriptions are presented in Appendix C)

The Study Area is devoted mainly to residential use adjacent to the central business district. The commercial areas are allocated along the main streets. The agricultural areas are found in the northern and eastern parts of the Study Area (Ref. Fig. 2.12)

8.3 EXISTING DEVELOPMENT PLAN AND PROJECT

There are two development plans; "The Fifth 5-year Development Plan (NESDB)" and "The Strucutral Plan for Bangkok Metropolis and its vicinity (Department of Twon and Country Planning, DTCP)".

a) The Fifth 5-year Plan

This plan emphasizes a strategy to stimulate economic activities in other regions outside the capital.

b) The Structural Plan for Bangkok Metropolis and its vicinity

The DTCP made the structural plan and had public hearings from 1976 several times, aiming at the authorization of the Structural Plan under the City Planning Act.

The DTCP could not get a public consent and is now revising the plan, aiming at public hearings in 1984.

According to the latest plan (1982), the western parts of the Study Area are allocated to be an urbanized area, and the eastern parts are to remain as an agricultural area.

On the other hand, major projects such as industry, housing and new airports are allocated in the outer suburbs beyond the Study Area.

8.4 URBAN DEVELOPMENT POLICY

Taking account of the situation of the existing urban development plan for 2000 which is not authorized, the Study Team has proposed the urban development policy (Fig. 8.3) for an orderly development of Bangkok from a city planning viewpoint. Under this development policy, Bangkok is classified as (1) Urban Development Area, (2) Urban Control Area and (3) Outer Development Area. And the Study Area is divided into the Urban Development Area and the Urban Control Area.

8.5 FUTURE LAND USE

In order to project the future land use for the Study Area, the future population and extent of the urbanized area first have to be estimated.

The population and urbanized area in the year 2000 are estimated to be 2,500,000 persons and 230 km^2 respectively. The methods of estimation are summarized in Figs. 8.4 and 8.5.

To project future land use, the following factors were taken into consideration:

a) Vacant lots which are surrounded by an existing built-up area, will be given priority as a future urban areas.

b) Under the development policy and also taking into account of the past trend of urbanized area, future urban areas will be adjoining the existing built-up areas.

c) Flood prone areas found by the flood damage survey will be excluded from future urban areas except for special cases.

d) Projected development areas will be given priority as future urban areas.

The basic policies of future land use plan are as follows:

a) Urban Development Area and Urban Control Area

The Urban Development Area, which is estimated as 230 km^2 in 2000 will be planned to adjoin the existing built-up area.

On the other hand, the Urban Control Area which is estimated as about 270 km^2, is located in the northern and eastern parts of the Study Area.

b) Commercial Center

Lat Phrao, Bang Kapi, Bang Khen and Phra Khanong will be developed or re-developed as commercial centers.

c) Road Network

Within the inner and outer ring roads, the road network for the Study Area will be formed on the radial-ring pattern.

d) Population Density

For the decision of a future required urbanized area, a population density of the urban development area is planned to be 100 persons per ha in the year 2000 which is considered suitable for human-life, taking into account of the followings:

1. Population density of many districts such as Phra Nakhon, Pom Prap, Patum Wan, Sam Phan Thawong, Bang Rak, Yannawa, Dusit, Phayathai, Huai Khwang, Thonburi, Klong San, Bangkok Noi and Bangkok Yai (locations of these districts are shown in Fig. 16.3) in the Bangkok Metropolis are over 100 persons per ha.

2. The typical space-image under the population density of 100 persons per ha shown in Fig. 8.6 seems to be suitable for land use plan.

3. If the example of Tokyo is described as reference, the average population density of 23 wards of Tokyo is about 150 persons per ha in 1980 which seems to be rather crowded.

The result is shown in Fig. 8.7.

8.6 CONCLUSION

The estimated population and urbanization area in the year 2000 were estimated as 2,500,000 and 230 km^2 where they are 1,160,000 and 148 km^2 at present.

In order to cope with such rapid urbanization, substantial efforts should be taken for an orderly development of the city along with the successful execution of the flood protection/drainage project.

Chapter 9 LAND SUBSIDENCE

9.1 LAND SUBSIDENCE IN THE YEAR 2000

The land subsidence due to excessive groundwater withdrawal has greatly aggravated the flood problem in the Study Area.

The Asian Institute of Technology (AIT) made a comprehensive study on the investigation of land subsidence in Bangkok with a detailed mathematical model. Several causes of groundwater withdrawal and their effect on land subsidence were studied. Based on the results of the review of AIT's Report, the future land subsidence for the Study Area is predicted for up to the year 2000. (Detailes are explained in Appendix D)

At the meeting between MWWA and the Study Team in August, 1983 it was reported that the latest MWWA surface water supply plan had been delayed for about 2 years. For the purpose of setting a basic condition of this Preliminary Study for Flood Protection/Drainage System, the Study Team considers that the execution of the latest MWWA Plan will be delayed for five years.

Based on this condition, the estimated amount of land subsidence between 1983 and 2000 will be 1.0 meter in the critical area and 0.7 meter in other areas. The critical area is the southwestern parts of the Study Area as indicated in Fig. 9.2 which shows the predicted ground elevation in the year 2000, and a cross section is shown in Figs. 9.3 and 9.4. In the year 2000, most of the Area is estimated to be under mean seal level, which will make it difficult to have stormwater runoff directly into the River by gravity flow.

9.2 RECOMMENDATIONS OF THE PREVENTION OF LAND SUBSIDENCE

To prevent land subsidence in the Bangkok area, the groundwater level must not be allowed to be lowered any further.

Based on the AIT study, serious efforts should be exercised to limit the grondwater use to 0.6 million m^3/day from the present groundwater withdrawal rate of over 1.0 million m^3/day.

The present rate of groundwater utilization cannot be sustained for a long period in the future. It is advisable that strict control on groundwater utilization in the private sector be started as eary as possible. It is recommended to establish a charging system to private consumers according to the quantity extracted.

It is found that the areas where land subsidence is severe are also the areas with an inadequate public water supply system. So it is recommended that an adequate surface water supply system be provided to all areas where there are demands for water supply.

Incidentally, the exact execution of MWWA's Master Plan according to its schedule is indispensable for the prevention of land subsidence in the Study Area.

9.3 CONCLUSION

Land subsidence in the year 2000 in the critical area and other area was estimated as 1.0 and 0.7 meters respectively.

Since land level is one of the fundamental conditions for flood protection and drainage, the countermeasures taken by relevant government organizations have essential importance for validity of this project.

Chapter 10 GENERAL CONCEPT OF FLOOD PROTECTION/DRAINAGE SYSTEM

The general concept for flood protection measures are proposed in this Chapter, based on the all information described in preceding chapters, especially causes of flood and flood damage described in Chapter 6. (Figs. 10.1 and 10.2)

Firstly, flood plain management is described, and then the structural measures for the flood protection/drainage system is described. Basic idea for the system is the establishment of polder system same as the Master Plan proposed by CDM.

10.1 FLOOD PLAIN MANAGEMENT

Alleviation of flood damage can not be economically obtained only by structural measures. Generally, the required investment for national projects amount to enormous sums. Consequently, not only technical measures but also social measures should be associated with each other. The following measures are considered indispensable for the efficient performance of the Project.

1) Identification and Publicizing of Flood-Prone Area

The announcement of flood-prone area to the public is very important. This makes the people living at the site take necessary countermeasures beforehand and new comers to the site will be able to select a suitable place for new housing.

2) Land Use Regulations

Rapid unplanned urbanization since 1970s has been turning paddy fields in the Study Area to residential, commercial and industrial areas. The landfill due to urbanization has taken place mainly along the existing roads. This ribbon style urban development has hampered the normal and hopeful urban development in the Study Area.

Therefore, a normal and orderly developing land use and urban development plan is needed so that water management in each section can be made according to the development plan. The Green Belt Area, east of the Study Area has been already declared as agricultural area.

The eastern part of the Study Area ia allotted to agriculture whilst western part is to be an urbanized area according to the land use plan made by the Study Team. The required urbanized area up to the year 2000 is estimated by the Study Team to be about 230 km^2, or about half of the Study Area. The western part is allotted as an urban development area and the eastern part should be conserved as an urban control (agricultural) area. (Fig. 10.3)

The construction of housing complex and commercial/industrial houses in the proposed urban control area should be discouraged not to create new flood problem until at least the year 2000. In this regard, it is necessary to obtain public concensus for the project. Under the public concensus, the establishment of zoning act or land use regulation should be enacted. Based on these act or regulartion, BMA will periodically inspect the site systematically.

3) Encouragement of Individual Flood-Proofing Measures

The structual flood protection/drainage system is planned in the western parts of the Study Area which are proposed as the Master Plan area (Refer to Chapter 15). However, new buildings will suffer from flooding for a long time until the project is completed. Therefore to avoid newly created flood problem, houses on landfill, traditional Thai-style house and flood-proof building especially those in flood-prone area (Refer to, for example, Fig. 4.1) are encouraged. Similarly, those measures are encouraged in the urban control (retarding) area.

All main roads in the Study Area regardless to Master Plan area and retarding area should be elevated in order not to be flooded, because they are very important for social activity.

4) Emergency Flood Fighting and Flood Warning Systems

Maximum high water level at Memorial Bridge (Bangkok) of the 7-day forecast has been performed weekly since 1979 by the Flood Forecasting Center at the Electricity Generating Authority of Thailand (EGAT).

Hourly rainfalls at 24 stations and water levels in several klongs mainly in the central area of Bangkok have been recorded since 1980 by the Department of Drainage and Sewerage (DDS). Based on these data, flood forecasting and flood management have been improved. To further improve forecasting 11 automatic water gauges and to play an important role for the collection of data on rainfall and water level in the study Area, a telemetering system should be established. Based on the collected data the analysis on flood forecasting should be made systematically in the operation center in DDS. Then, the warning system should be established to timely inform the results of the flood forecast to the public and to prepare flood fighting for reducing flood damage.

5) Flood Protection Committee

Since the project is of direct interest to residents in the Study Area, it will be necessary to set up a committee where representatives of the residents are given a chance to understand the outline of the project. Especially for the subject of klong widening and polder construction which will involve the re-location of residents along the site, and also for the subject of levying tax or collection fee from residents, thus it will be necessary to organize a Flood Protection Committee for talks with residents in the area.

Coordination with other flood protection projects in the neighboring region will be another important function of the Flood Protection Committee. This subject is already taken into consideration by the committee on Flood Protection and Solution in BMA and Circumference, the urgent committee established by the order of the Prime Minister in October, 1983.

10.2 STRUCTURAL MEASURES

1) Prevention of Land Subsidence

Reduction of amount of grondwater use is the indispensable solution to stop further land subsidence. The Metropolitan Water Works Authority (MWWA) has already taken a step towards substituting surface water for groundwater.

Although the project cost of surface water development is very high, this cost could save flood protection costs because very costly pumps and high embankments will be needed once the land has subsided. Accordingly, an MWWA surface water plan should be developed as rapidly as possible from the viewpoint of flood protection.

2) Prevention of Inflow from Outer Areas

Much water flows into the Study Area from outer areas through the many klongs. These man-made klongs have turned the vast sterile central plain including the Study Area into fertile paddy fields especially after completion of the Greater Chao Phraya Project.

According to the result of the study, in some cases about half the amount of stormwater within the Study Area during the rainy season comes from the outer areas, through the man-made klongs and the remaining amount comes form rain precipitated within the Study Area.

In the light of above situation, the prevention of inflow from the outer areas is very important. Toward this goal, the Green Belt Project has been planned and construction started in 1983 and is expected to be completed within three years. Prevention of inflow from the outer areas makes an excellent basis for the flood protection and the completion of the Green Belt Project has first priority in the Study Area.

3) Prevention of Inflow from the Chao Phraya River

The area alongside the Chao Phraya River suffers from annual flooding at time of high river level and high tide. Most parts of the Study Area near the Chao Phraya River will become lower than mean sea level in the near future even if groundwater withdrawal is reduced considerably. The lowest area, Ramkhamhaeng will subside to 0.8 meters below mean sea level (MSL). The surrounding areas, parts of Phra Khanong and Bang Kapi will also reach 0.5 to 0.7 meters below mean sea level.

Accordingly, the construction of embankments along the Chao Phraya River becomes crucial for flood prevention. These embankments are necessary not only within the Study Area but also the adjoining areas.

Both the City Core Project and the Samut Prakan Seawall Project have planned to construct embankments in their respective project area. Therefore, embankments along the Chao Phraya River from the border of the city core project, Klong Bang Sue to the Border of the Green Belt Project, Klong Rang Sit should be constructed for flood protection in the Study Area.

Needless to say, gates at the mouths of the klongs are necessary.

4) Conservation of Retarding Area

Paddy fields are still remained in the eastern parts of the Study Area. Consequently, a large amount of stormwater is naturally stored in the paddy fields. This has reduced flood water in the western, urbanized area. The western area will become lower than the eastern area due to different rate of land subsidence. As a result, the western area will collect stormwater from the eastern area. Therefore, in order to reduce a flood discharge in the western, urbanized area, water inflow from the eastern area (urban control area) to the western area (urban development area) should be choked.

If no measures is taken against unplanned urbanization in the eastern area, a new larger flood problem will be created. To avoid new flood problem, urbanization should take place according to the land use plan. An urban development of eastern area should be waited until the western parts will have been developed by the year 2000.

5) Improvement of Drainage Capacity in Protection Area

Taking account of land subsidence and high water level in the Chao Phraya River, it is clear that the klong system alone cannot drain storm floods in the allowable duration unless a pumping system with appropriate capacity is provided. In order to provide protection against stormwater flood throughout the rainy season, it is necessary to install a stormwater collection system and drainage pumps with a definite capacity. The system has to be combined with the maximum use of the klongs.

10.3 CONCLUSION

The Study Area is recognized as flood-prone. The flood plain management will play an important role for the successful operation of the flood protection/drainage system.

The following measures are proposed as a flood plain management:

1) Identification and Publicizing of Flood-Prone Area

2) Land Use Regulations

3) Encouragement of Individual Flood-Proofing Measures

4) Emergency Flood Fighting and Flood Warning Systems

5) Flood Protection Committee

For the flood protection and drainage system, the following basic conditions are proposed.

1) Prevention of land subsidence

2) Prevention of inflow from outer areas

3) Prevention of inflow from the Chao Phraga River

4) Conservation of Retarding Area

5) Improvement of Drainage Capacity in Protection Area

Chapter 11 METHODOLOGY OF STUDY FOR FLOOD PROTECTION MEASURES

Based on the general concept of the flood protection/drainage system mentioned in the preceding chapter, the methodology of the Study was formulated through the following three phases.

Firstly, the criteria for the formulation of the drainage area and the setting out the priority of the drainage area were established. Secondary, the basic idea on the zoning of drainage area and flood protection/drainage system was studied. Thirdly, the procedure of the hydrological-hydraulic study was described.

11.1 CRITERIA FOR THE FORMULATION OF THE DRAINAGE AREA

The criteria for the formulation of the drainage area are described as follows:

1) Topography and Land Subsidence

Topography is the main factor for the formulation of drainage area. Especially, the location of main klongs and the drainage basin play a definitive role for the zoning.

Originally low-lying western parts of the Study Area (Ref. to Fig. 2.3) will become lower further. (Figs. 9.2 to 9.4) due to land subsidence. Hence, western parts and eastern parts will become independent drainage area.

Eastern parts will act as a retarding area topographically.

2) City Planning

City planning is also a base of the formulaton of drainage area. Especially, land use planning, distribution of population, administrative zoning paly important roles for the zoning.

The urban development area in 2000 will be planned to be located in the western parts, whilst the urban control area is located in the eastern parts. (Ref. to Fig. 8.6)

3) Trend of Past Flood Damage

Past trend of flood damaged areas and predicted future flood areas are taken as definitive factors in formulating a drainage area.

Western parts have suffered and will suffer from flood damage more severely than the eastern parts. (Ref. to Fig. 3.2 and 4.1)

4) Location of Highways and Railways

The highways and railways in the Study Area are constructed on raised bank with elevation of about 2 meters above MSL, higher than the surrounding areas. Therefore, they are acting as natural water barriers, and can be used as boundaries of drainage zones. (Ref. to Figs. 2.13 to 2.14)

11.2 CRITERIA FOR SETTING OUT THE PRIORITY OF THE DRAINAGE AREA

The criteria for setting out the priority of the drainage area are described as follows:

1) Past Flood Damage

A priority will be given to the areas where past flood damage was and predicted flood damage will be more severe and frequent.

Flood damage is often observed in the western parts of the Study Area, where the flood damage is expected to become more severe in the future due to the land subsidence.

2) Effective Investment

A priority will be given to the area from which a large economic return is expected by the execution of the flood protection measures.

According to the estimation of future land use by the Study Team, the eastern parts of the Study Area which are allotted for urbanized area are deemed to be a high priority area.

3) Economic Activities in the Area

From a viewpoint of national economy, the area with higher economic activities should be given a higher priority. There are commercial districts in the western parts of the Study Area, for example.

4) Others

Besides the above-mentioned major criteria, the following factors should also be taken into consideration.

1. Urgency of flood protection works

2. Consensus and cooperation of residents

3. Difficulty of acquisition of land needed for drainage facility

4. Difficulty of construction works

11.3 STUDY ON ZONING OF DRAINAGE AREA AND FLOOD PROTECTION/ DRAINAGE SYSTEM

1) Retarding Area

In the preceding chapter, the establishment of a retarding area is proposed. In order to utilize an existing natural water retaining capability to the maximum extent, the conservation of a retarding area is essential. The future land use planning has direct effect on realizing this idea, and needs to have consistency with drainage requirements. The urbanization and natural water retarding function should be combined/ harmonized. (Fig. 11.3)

Thus, the Study Area will be divided into two areas which are an urban development area and a retarding area. The urban development area will be protected by the flood protection/drainage system that hereinafter called as the "protection area" or Master Plan Area.

The retarding area should be conserved in their existing status with natural flow retarding functions. This area is called as the "retarding area", which is bounded from the protection area with flood protection barriers consisting of existing and planned roads and dikes.

The proposed boundary between the protection area and retarding area is explained in Chapter 15 "Proposed Master Plan Area".

2) Protection Area

The basic flood protection/drainage system in the protection area will be decided by the zoning of the area based on the polder system. (Fig. 11.5)

Based on the criteria mentioned in the preceding sections, the following three alternatives on flood protection/drainage system were selected mainly considering topography, location of main klong, drainage basin, land subsidence, city planning, trend of past flood damage and highway.

a. Alternative I : Two-Polder System

The Protection Area constitutes two polder units enclosed by flood protection barrier. One polder is the area covered by Klong Bang Khen and Bang Sue drainage areas. The other is the area covered by Klong Phra Knanong, Saen Saep and Bang Na drainage areas. Stormwater is discharged to Chao Rhraya River from four pumps and gates installed at the lower reach of the klongs. (Fig. 11.4–11.5)

b. Alternative II : Multi-Polder System

The Protection Area is divided into several polders. Each polder is provided with flood protection barriers, embankments, pumps, gates and other facilities. Each pump discharges stormwater into the klongs outside of the polder.

c. Alternative III : Mixed System

This system is a mixed system of the two systems. Special low land and important areas will be enclosed by inner polders.

11.4 PROCEDURE OF HYDROLOGICAL AND HYDRAULIC STUDY

This section describes the procedure of the hydrological-hydraulic study for flood protection/drainage system. The study will be made in the order of five steps as shown in Fig. 11.1 and Table 11.1

As the first step, the impact of the Green Belt Project will be evaluated. The evaluation of the impact of conservation of the retarding area will follow as the second step. As the third step, the zoning of the drainage area and flood protection/drainage system will be evaluated based on the alternatives established in the previous section, 11.3. The most appropriate flood protection/drainage system will be selected after the comparison of alternatives during a Master Plan study. In this Preliminary Study, a rough study for the alternative III, "Mixed System" will be made as a sample calculation.

The results of the hydrological and hydraulic study are described in Chapter 14, based on the established hydrological-hydraulic model (Chapter 12), and hydrological design criteria (Chapter 13).

Table 11.1 STEPS OF ANALYSIS FOR FLOOD PROTECTION/DRAINAGE SYSTEM

Key Word	Step	
Green Belt Project	Step I	Impact of Prevention of Inflow from Outer Areas (Impact of the Green Belt Project)
Conservation of Retarding Area	Step II	Impact of Conservation of Retarding Area
Zoning of Drainage Area	Step III	Zoning of Drainage Area and Basic Flood Protection/Drainage System
Polder System	Step IV	Study of Inner Polder Unit
Polder System	Step V	Study of Inner Polder Unit

1) *Impact of the Green Belt Project (Step I)*

The impact of the Green Belt Project will be examined in order to determine how it will contribute to flood relief in the Study Area. Fig. 11.2 shows the direction of strom-water flow from the outer area with and without the execution of the Green Belt Project.

2) Impact of Establishment of Retarding Area (Step II)

After the impact of the Green Belt Project has been examined, the impact of the establishment of retarding area will be evaluated. (Fig. 11.3)

3) Zoning of Drainage Area and Flood Protection/Drainage System (Step III)

After the impact of the retarding area has been evaluated, the border line between the protection area and the retention area will be decided. Based on the alternatives for zoning of drainage area and flood protection/drainage system as mentioned in the preceding section, the hydrological and hydraulic study will be made and the optimum system will be selected during the Master Plan Stage. (Figs. 11.4 and 11.5)

In this Preliminary Stage, however, only a rough study for alternative III, "Mixed System", will be made as a sample culculation.

4) Study of Inner Polder Unit and Total Drainage system (Steps IV & V)

The study of the drainage system inside the Polder Unit and the study of total drainage system will be made during the Master Plan Stage.

11.5 CONCLUSION

As the methodology of the study, the criteria for the formulation of the drainage area were first defined and the priority of drainage area set out.

Based on these criteria, the basic idea on the zoning of drainage area and flood protection/drainage system is studied/proposed.

Then, the procedure of the hydrological and hydrulic study is established to be carried out in the following five steps.

1) Investigation of Impact of Prevention of Inflow from Outer Area

2) Investigation of Impact of the Conservation of Retarding Area

3) Zoning of Drainage Area and Basic Flood Protection/Drainage System

4) Study of the Inner Polder Unit

5) Study of the Total Drainage System

The hydrological and hydraulic study of steps 1), 2) and a part of 3) are undertaken in this Study. The study results are described in Chapter 14. The studies of Steps 3), 4) and 5) will be conducted in the Master Plan Stage.

Chapter 12 SELECTION AND CALIBRATION FOR HYDROLOGICAL AND HYDRAULIC MODEL

This chapter explains the adaptability of the models such as the Two Basin Model, Bi-Dimensional Model and Polder Drainage Models for the evaluation of the flood characteristics in the Study Area.

12.1 GENERAL

In order to evaluate the flooding characteristics in the Study Area, general hydrological flooding models are prepared. The outlines of these models are listed in Figs. 12.1 and 12.2.

The application of the proposed models for the study of flood characteristics in the Study Area are shown in Fig. 12.3.

12.2 SELECTION OF MODELS

The Study Team selected three models for actual application based on the following reasons.

1) Two Basin Model

The two basin model is simple and easy to compute, however, it can describe the essential flood conditions fairly well for low-lying areas like the Study Area. Especially, the typical flood in the Study Area is a long duration storage-type flooding. Therefore, the model which contains a continuity equation is considered effective.

2) Bi-Dimensional Model

The bi-dimensional model is a more accurate model than the two basin model. This model which consists of a continuity equation and a kinetic equation can describe more detailed flood conditions. The flood condition in a small limited area can be obtained by this model.

In this Preliminary Study this model is calibrated and identified for adaptability to the actual application.

3) Polder Drainage Model

For the study of polder drainage, the hydrological models shown in Fig. 12.2 were selected. These models are sufficient to evaluate the capacities of pumps, gates and storage by the klongs within the polder unit.

12.3 CALIBRATION STUDY OF MODELS

1) Calculation Area for Modeling and Basic Zoning

The calculation area for hydrological and hydraulic modeling is decided by the physical conditions, especially the roads and railway which are existing hydraulic boundary lines. Fig. 12.4 shows this calculation area contrasting with the Study Area in BMA.

2) Two Basin Model

The two-basin model is used to calibrate flood water levels in 1983 and the flood marks of 1980 which were surveyed by the Study Team. The divided two-basins as shown in Fig. 12.5 is decided by the similarity of water levels and flood marks, considering the proposed protection area and retarding area.

Figs. 12.6 and 12.7 show the observed water levels at water level gauge stations, the locations of which are shown in Fig. 12.5, and the calculated water levels in the assumed two basins in 1983; the retarding area and the protection area respectively.

Similarly, Fig. 12.9 shows the comparison of the surveyed flood marks and calculated water levels for 1980 in the two-basins.

Fig. 12.8 shows a comparison between longitudinal observed water level and calibrated water level in 1983.

As can be seen in these figures, the calculated water levels are consistent with past flood records. Therefore, the two-basin model is found to be adaptable in the general evaluation of the flood.

3) Bi-Dimensional Model

The Study Area is divided into 31 components for the hydraulic calculations based on the existing roads and railways as physical boundaries for the bi-dimensional model. Fig. 12.10 shows these divisions.

Fig. 12.11 indicates the calibrated water levels, while Fig. 12.12 indicates the calibrated maximum water levels and inundation depth in 1983. These results are consistent with past flood records.

4) Polder Drainage Model

In order to establish a suitable and effective polder drainage system, it is necessary to apply some hydrological models such as the rainfall model, the runoff model and the one basin model.

In this study, typical methods of use of these models, as shown in Fig. 12.2, were introduced for reference. For a sample analysis for these methods, the Remkamhaeng Site was selected and the results are shown in Fig. 12.13.

12.4 APPLICATION OF MODELS TO THE PRELIMINARY STUDY

The simulated storage volumes by the two basin model and bi-dimensional model for the whole Study Area, and the simulated storage volumes in the 1983 flood are practically the same shape and amount. (refer to Appendix Fig. E 28)

Therefore, the two basin model is applied to evaluate the general characteristics of flood, namely; the impact of the Green Belt Project (Step I) and the impact of the conservation of retarding area (Step II).

On the other hand, the bi-dimensional model is applied to evaluate polder units, drainage areas etc., because a more precise flood condition in each specific area is necessary to determine the size and capacity of drainage facilities coupled with the flooded area and flood depth (Step III).

12.5 CONCLUSION

The Study Team selected the three models (Two Basin Model, Bi-Dimensional Model and Polder Drainage Model) and calibrated these models for the 1983 flood. Based on the result of calibration, these models are identified as suitable to evaluate the flood protection measures.

Chapter 13 HYDROLOGICAL DESIGN CRITERIA

In this Chapter, the criteria for hydrological design was studied/established. In order to establish the hydrological design criteria, the hydrological survey presented in Appendix F was carried out based on the surveyed and calculated data. Fig. 13.1 shows the procedure for the decision of hydrological design criteria.

13.1 HYDROLOGICAL SITUATION IN THE STUDY AREA

As a result of the hydrological survey, the hydrological situation in the Study Area is as follows:

1) Hydrological Impact

Floods in the Study Area frequently occur between September and November each year, mainly due to two hydrological impacts, a extreme rainfall and the high water level in the Chao Phraya River.

2) Design Rainfall for Drainage System

For the analysis of drainage facilities inside the polders, the short term rainfall within one day is considered adequate in calculating the stormwater runoff, considering the size and the type of drainage system inside the polders.

On the other hand, taking into account the long-duration flood recently experienced, the design of the main klongs is considered suitable when based on the long term rainfall and external high water level.

3) Rainfall Pattern

The pattern of the short term rainfall is a front concentration type and its duration is less than 9 hours as indicated in Fig. 13.3.

The long term rainfall patterns during the flood season are consistent as indicated in Fig. 13.6. However in the 1983 floods, the monthly rainfall in August and the number of rainy days from August to mid-November are higher than the others.

4) Probable Rainfall Intensive Duration Curve

The relationship between rainfall intensity and duration obtained by means of the Thomas plotting method and the least squares method, is presented in Fig. 13.2. The probable hourly rainfall intensity in this Study is approximately 8% larger than that of the CDM Plan and almost same with that of NEDECO Study.

5) Probability of long term rainfall and water level of the Chao Phraya River in recent typical floods

The probability of real 3-month rainfall between August and October in 1980 and 1983 floods are 3.4 and 25-year return period respectively as shown in Fig. 13.4.

The recorded mean water level (MWL) of the Chao Phraya River over the same period, which has influence upon the discharge into the Chao Phraya River, is approximately same as the MWL for a 5-year return period as presented in Fig. 13.5.

13.2 HYDROLOGICAL DESIGN CRITERIA IN RELEVANT PLANS

1) CDM Master Plan

In the CDM master plan mentioned in Chapter 5, 5-year frequency rainfall was used in the design of the klongs connecting to the polders and 1 to 5-year frequency rainfall according to the kind of land use plan, was adopted in designing the drainage system inside the polder. Rainfall amount decided by CDM was 67 mm/hr with a 5-year return period. However much data about rainfall has been collected since, 67 mm/hr rainfall was found to be a about 2.6 year return period.

The flood protection barrier of each polder and main drainage facilities, such as Padung Krung Kasem and Rama IV pumping stations were planned based on a 100-year frequency flood levels (1.8 m above MSL at Bangkok Port) in the Chao Phraya River as the design external water level. (Table 13.1)

The interior klongs and the pumping stations are designed by setting up the maintained elevation of water surface in the klongs as followings.

During the rainy season	:	Maximum, 0.77 meter above MSL
		Minimum, –0.28 meter MSL
During the dry season	:	Minimum, the mean ground water level or 0.27 meter above MSL

2) NEDECO Study

As described also in Chapter 5, the NEDECO study is at the feasibility study and detail design stage for the Core Area in Bangkok. According to the NEDECO's draft general study report, the design rainfall for the drainage facilities in the polders is adopted 2-year frequency rainfall (hourly rainfall intensity, 61.5 mm/hr) or which duration is 3 hours.

Flood protection barrier and main drainage facilities located along the Chao Phraya River is designed for high water levels of 100-year return period in Chao Phraya River, which is approximately 10 cm higher than that of CDM plan.

In designing the interior klongs and pumping stations, the average polder water level is decided in principle around MSL −0.25 meter, assuming land level between MSL +1.00 meter and +1.50 meter. However the drainage capacity of these facilities are designed by studying the relationship between the drainage capacity and the regional characteristics such as topography, storage capacity and capacity of existing drainage facilities.

13.3 ESTABLISHMENT OF HYDROLOGICAL DESIGN CRITERIA

Based on the foregoing, the following hydrological design criteria for studying the flood protection/drainage system were established.

1) Drainage Facility inside the Polder

For the design rainfall in calculating the runoff inside the polder, a 5-year frequency rainfall (hourly rainfall intensity, 76.0 mm/hr) having a front concentration type as indicated in Figs. 13.2 and 13.3 is adopted. The calculation will be also made for 2-year frequency rainfall (58.7 mm/hr) as the comparative study.

As to a design scale for drainage system in urban area, 1 to 10-year frequency rainfall is generally adopted in many other countries, depending on the regional characteristics. The examples are described as follows:

Malaysia	:	1 to 5-year frequency depending on the regional characteristics (2-year return period, 66 mm/hr, 5-year return period 78 mm/hr)
Manila	:	1-year frequency (50.5 mm/hr), not allowed inundation 10-year frequency (77.4 mm/hr), allowed inundation. . . 20.0 cm
Japan	:	50 – 60 mm/hr (equivalent to 5 to 7-year frequency)

Since Bangkok is the capital of Thailand, and one of the largest cities in Southeast Asia, this important national project should be planned in view of the long range future. Therefore, the design scale of this project should be selected on this line. It is very difficult to change the degree of flood protection/draiange after execution of the project. It is desirable to adopt a value as high as possible within the financial limit for the design scale of rainfall inside the polders. However, it is also advisable to be consistent with the relevant projects in the neighboring areas.

Based on the fact mentioned above, it is considered as appropriate to adopt a 5-year return period in principle. The study will be made for the 2-year return period rainfall for the comparative study.

In designing pumping stations and gates inside the polders, the high water level of the external klong calculated on the 5-year frequency rainfall is adopted.

In planning the drainage facility, temporary inundation is considered for the retention and low land areas. The drainage capacity will be decided in consideration of the regional characteristics such as topography, storm water storage capacity, property and so on.

2) Main Klong Drainage Facility

A 5-year frequency rainfall having a real rainfall pattern in the 1980 flood is adopted as design rainfall for main klongs connecting the polders.

The main klongs such as Klong Phra Khanong, Klong Saen Saep and Klong Lat Phrao, are one of the main drainage facilities. As experienced in the 1983 floods, the floods caused by the overflowing of these klongs were observed in many areas as shown in Fig. 4.1. This caused a great flood damage.

From the result of the probability analysis carried out, the rainfall between August and November in 1980, having a typical rainfall pattern is estimated at 3.4-year return period only 10% less than 5-year return period in a 3-month rainfall. The rainfall in 1983 was extraordinary and estimated as a 25 year frequency rainfall in a 3-month rainfall.

The external water level for the design at the pumping stations and gates facing the Chao Phraya River will be the 100-year return period.

3) *Flood Protection Barrier along the Chao Phraya River*

Design water level for flood protection barrier connected to the Chao Phraya River is to be the high water levels for the 100-year return period, considering the socio-economic situation of the region, importance of the facilities and consistency with the Core Project.

The relation of hydrological design criteria of CDM Plan, NEDECO Study and JICA Preliminary Study is shown in Table 13.1.

Table 13.1 HYDROLOGICAL DESIGN CRITERIA OF CDM PLAN, NEDECO STUDY AND JICA STUDY

	Item	CDM PLAN	NEDECO STUDY	JICA STUDY	Remarks
Polder	Rainfall				Examples of other countries
	(1) Design Scale	For drain (i) Commercial Industry 1/N=1/5 67mm/hr (ii) Residential 1/N=1/2 57mm/hr (iii) Green 1/N=1/1 47mm/hr For Klong 1/N=1/5 67mm/hr	1/N=1/2 61.5mm/hr	1/N = 1/5 76.0 mm/hr.	Malaysia: 1/N=1/2, 66mm/hr, 1/N=1/5, 78mm/hr Manila: 1/N=1/1 (51mm/hr) 1/N=1/10 (77mm/hr) Japan: 1/N=1/5 - 1/7, 50mm/hr - 60mm/hr
	(2) Pattern	Front concentration type hyetograph	Same as CDM	Same as CDM	
	(3) Calculation Period	12 hours	3 hours	Within one day	
	Water Level				
	(1) Internal	Rainy season: MSL max. 0.77 m MSL min. -0.28 m Dry season: Mean ground water level or MSL 0.27m	In principle, average water level: MSL -0.25m	Study in Master Plan	
	(2) External	1/N=1/100 (Chao Phraya River)		High water level of external klong calculated based on 5-year frequency rainfall	
Main Klongs	Rainfall				
	(1) Design Scale	No Study	No Study	1/N=1/5	
	(2) Pattern	-	-	Real rainfall pattern in 1980	
	(3) Calculation Period	-	-	3-month	
	Water Level	No Study	No Study		
	(1) Internal	-	-	Study in Master Plan	
	(2) External	-	-	1/N=1/100 (Chao Phraya River)	
Barrier	Water Level of Chao Phraya River				
	(1) Design Scale	1/N=1/100	1/N=1/100	1/N=1/100	
	(2) Water level at Bangkok Port	1.80 m above MSL	1.90 m above MSL	1.9 m above MSL	

13.4 CONCLUSION

From the study result, the following hydrological design criteria are established.

1) Rainfall for Calculating Discharge in Polders

A short duration rainfall of a 5-year return period with a front concentration type hyetograph is adopted in principle and a 2-year return period for comparison.

2) Rainfall for Calculating Discharge in Main Klongs

A long duration rainfall of 5-year return period having the real reainfall pattern of the 1980 flood is adopted as design rainfall.

3) Water Level of Chao Phraya River

Water level in 100-year return period is adopted as design water level.

4) Drainage Capacity in Polders

The temporary inundation is considered for retention and low land area. The drainage capacity will be decided in consideration with the regional characteristics. istics.

Chapter 14 RESULT OF HYDROLOGICAL AND HYDRAULIC STUDY

In this chapter, the result of hydrological and hydraulic study is described based on the description in Chapters 11, 12, and 13.

14.1 GENERAL

The two basin model is applied to evaluate the effect of the Green Belt Project, that is to say, the effect of the prevention of inflow from the outer areas of the Study Area, and the effect of the retarding area.

The estimation for the effect of improvement of drainage facilities, such as pump and gate stations is done by using two basin model.

The main parameter to analyze the flood situations are as follows:

Main Parameter

F : Rainfall and inflow from outer area
Fo : Capacity of flood control facilities
Ls : Land subsidence

For simplification, the Study Team calls the barrier of the Green Belt Project as the "first barrier" and partition barrier between the retarding area and the Master Plan Area (or called as Protection Area) as the "second barrier".

The used calculation conditions are shown in Table 14.1.

Table 14.1 BASIC CALCULATION CONDITIONS

	Two Basin Model	Bi-Dimensional Model
Rainfall	Observed average area daily rainfall in 1980 and 1983	Observed average area daily rainfall in 1980
Topography	Condition in 1983 and 2000	Condition in 2000
Water Levels in the Chao Phraya River	Observed data in 1980 and 1983 Time interval: 2 hours	Observed data in 1980 Time interval: 1 hour
Calculation Period	Case in 1980 . . . Aug. to Nov. Case in 1983 . . . Aug. to Oct.	Sept. 15 – Oct. 31
Capacities of Gates and Pumps	Shown in Fig. 14.1	Shown in Fig. 14.11

Inflow amounts from the outer area of the Study Area are estimated as shown in Fig. 14.2 based on calibration study in Chapter 12. Evaluation cases for impact of barriers using two basin model are shown in Fig. 14.1.

Detailed description of the analysis is shown in Appendix E.

14.2 IMPACT OF THE GREEN BELT PROJECT (STEP I STUDY)

The boundary between the Study Area and the Green Belt Project area is the first barrier to prevent inflow from the outer areas. Almost all inflow from the outer areas cross this line, which was inspected by field investigation by the Study Team.

It is found that more than half of total water volume including rainfall within the Study Area, comes from the outer areas according to the analysis as shown in Fig. 14.2.

The Green Belt Project which prevents inflow from the outer areas into the Study Area is now under construction. This project can strongly relieve the flood conditions in the Study Area.

Inundated condition without the Green Belt Project for 1980 rainfall is shown in Fig. 14.3, while Fig. 14.4 shows the "with the Project" condition. Fig. 14.6 indicates the flood water levels of both with and without the Project.

For the rainfall in 1983, the results of the study using two basin model are shown in Figs. 14.8 to 14.10.

Simulated inundation area and flood water levels are shown in Appendix E.

Based on these tables and figures, following comments are described.

(1) In the existing topographical condition, the flood water level will be decreased to near the mean ground elevation level by the effect of the Green belt Project.

(2) In the protection area, however, the decrease of inundation is not sufficient especially for lower land.

(3) Under estimated topographical conditions in the year 2000, strong countermeasures are necessary, even though the Green Belt Project will prevent inflow from the outer areas.

(4) The existing klong arrangement leads the storm-water from the retarding area into the protection area, therefore, particularly the lower area in the protection area will be more deeply inundated under future topographic conditions.

In conclusion, the effect the of Green Belt Project is very large, and therefore, this Project should be strongly promoted.

14.3 IMPACT OF RETARDING AREA (STEP II STUDY)

The impact of the retarding area is shown in Fig. 14.5 and Fig. 14.7.

Simulated inundation area and flood water levels are shown in Appendix E.

Based on these figures,

(1) Under existing topographical conditions, flood water level will be reduced to almost near the mean ground elevation level, and it is clear that the flood area and flood duration will be much improved in the protection area by the effect of the second barrier.

(2) In the protection area under future topographical conditions, flood conditions will be relieved, but the simulated inundated depth and flood duration are still unacceptable. Therefore, the construction of flood protection works are necessary.

(3) In the retarding area, flood water levels with the second barrier are about 15 centimeters higher than the "without" condition. However, simulated inundation depths after construction of second barrier will be about 20 centimeters (under existing topographical condition) and 35 centimeters (under topographical condition in 2000). These depths can be admitted since the existing inundation depth is more than 50 centimeters which is much deeper than the simulated depth.

14.4 HYDRAULIC STUDY FOR DRAINAGE SYSTEM (STEP III STUDY)

In this section, a Mixed System (Alternative III), which seems to be an appropriate drainage system, is studied.

Fig. 14.11 shows an example of Alternative III, which indicates the tentative arrangement of polders including pumps and gates. The pump capacities are tentatively assumed to have the following specific capacity:

For Zone A (Retarding area) . . . . 0.06 $m^3/s/km^2$
For Zone B (Protection area : Phra Khanong, Bang Na). . . . . 0.90 $m^3/s/km^2$
For Zone C (Protection area : Bang Khen, Bang Sue) . . . . 0.12 $m^3/s/km^2$

The result of the calculation is shown in Figs. 14.12, indicating the simulated water level and observed inundation depth on September 29, 1980 when the maximum storage volume was observed in zone B. With the simulated conditions, a fairly good drainage condition is observed.

However, several inundated areas remain partly in protection area (zone B).

14.5 CONCLUSION

The followings are concluded from the study in this Chapter:

1. The effect of the Green Belt Project is very large.
2. The effect of the retarding area is also very large.
3. The proposed drainage system in protection area is to be a mixed polder system which corresponds to the drainage from each polder to main klong and the drainage from main klong to the Chao Phraya River.

Chapter 15 PROPOSED MASTER PLAN AREA

This Chapter explains the selection of the Master Plan Area and definition of survey area for the Master Plan. Firstly, the criteria for the selection of the Master Plan Area was established. Based on the established criteria, the alternatives for the Master Plan Area were studied from which the Master Plan Area was selected and the definition of the survey area for the Master Plan was made.

15.1 CRITERIA FOR SELECTION OF MASTER PLAN AREA

As has been proposed in Chapter 8 (Future Urbanized Area), the urban development area in 2000 should be in the western parts, while the existing paddy fields in the eastern parts should be maintained. And also as described in Chapter 10 (General Concept of Flood Protection/Drainage), the necessity of the conservation of existing paddy fields in the eastern parts has been emphasized for flood protection measures.

The selection of the Master Plan Area is, in fact to decide the border line between the urban development area to be protected from floods (the "protection area") and the eastern parts to be conserved (the "retarding area"). To cater for the future needs for land corresponding to the increase in urban development and population, it is preferable to increase the protection area as much as possible. However, from economic and financial viewpoints and other factors, the area should be limited because the cost for the flood protection measure amounts to an enormous sum. Main factors to be considered are as follows:

1) Need for future urbanized areas
2) Trends of past flood damage
3) Hydrological conditions
4) Physical boundary condition
5) Economic & financial conditions

The first priority will be given to the need for future urbanized areas, and then other factors described above. Finally the economic and financial conditions will be the decisive factor. At this stage of the Preliminary Study, it is considered preferable to select rather a large area worth protecting from flooding.

15.2 ALTERNATIVES OF THE MASTER PLAN AREA

The alternatives for the Study on the Master Plan area can be considered in the following five cases mainly based on the future land use, land subsidence, road network, hydraulic condition and present flood protection activities, etc. (Fig. 15.2)

(1) Entire Study Area (501 km^2)

(2) Area covered by the DDS flood protection activities (370 km^2)

(3) Area of low and medium housing density in the year 2000 (260 km^2)

(4) Area of medium density and part of the low density housing area in 2000 (200 km^2)

(5) Area of medium housing density in 2000 (170 km^2)

15.3 SELECTION OF THE MASTER PLAN AREA

The Study Team has selected case (3), the area of low and medium density in the year 2000 which is shown in Fig. 15.1, for the Master Plan. It is mainly based on the estimated urbanized area in the year 2000 which indicates a higher priority for flood protection.

1) Need for Future Urbanized Area

To accommodate estimated 2.5 million persons in the year 2000, the area of 230 km^2 is necessary in the Study Area derived from the study on the future urbanized area described in Chapter 8.

This required land should not be sprawled over the whole Study Area, but be allocated to specific area. Flood prevention measures covering the entire Study Area are difficult taking account of enormous financial burden.

Future Urbanized Area, the urban development area in 2000 is allotted to the western parts, while the existing paddy fields in the eastern parts should be maintained for city planning and the flood protection/drainage reasons.

These make, case (3) preferable.

2) Flood Damage

In the proposed Master Plan Area, urbanization has been taking place in parts and consequently flood damage has been increased.

Furthermore, the ground elevation in the proposed Master Plan Area will become lower than the retarding area due to differential rates of land subsidence depending on location. Accordingly, the Area will collect more storm-water, thus severe flood damage is expected to occur in the proposed Master Plan Area.

3) Hydrological Conditions

To prevent collection of more storm-water, a flood protection barrier along the border between the proposed Master Plan Area and the retarding area is proposed. From the Study results, flood conditions in the retarding area were proved to be no worse than the present condition due to the effect of the Green Belt Project.

4) Physical Boundary Conditions

Existing and planned roads and the railway alignments will be utilized as flood protection barriers which are necessary to protect low-ground areas from storm-water inflow from higher-ground areas.

5) Economic Conditions

According to the rough study on cost-benefit analysis, the positive benefit might be obtained in the proposed Master Plan Area. (Fig. 15.4) However, this cannot necessarily assure the expected benefit in the proposed Master Plan Area because a cost-benefit analysis and a cost estimation in the Preliminary Study stage are not precise. These analyses and estimates will be conducted in the Master Plan Study stage.

As described above, case (3) area was selected as the Master Plan Area. The border line was broadly defined by the roads alignments because of the effective use of roads as flood protection barriers.

15.4 DEFINITION OF SURVEY AREA FOR MASTER PLAN

The survey area for the Master Plan will be the same area as the Master Plan Area mentioned above.

15.5 CONCLUSION

Based on the selection criteria of the Master Plan Area, the Master Plan Area is proposed to be the area of low and medium housing density in the year 2000, with an area of 260 square kilometers.

Chapter 16 ORGANIZATION, OPERATION AND MANAGEMENT PLAN

In this chapter, the organizational and managerial aspects of implementing and operating the project are studied and some suggestions are presented.

16.1 ORGANIZATION OF BANGKOK METROPOLITAN ADMINISTRATION (BMA)

BMA is the regional government to administer the 24 districts of Bangkok Metropolis which has an area of 1,589 km^2. The governor and four deputy governors are appointed by the cabinet and the undersecretary by Minister of Interior while Bangkok Metropolitan Assembly is the formal body to govern BMA. (Fig. 16.1)

Various municipal services; police, medical, health, education, sanitation, social welfare, roads, canals and drainage are provided by BMA through 11 departments and 24 district offices. The public services such as water supply, mass transportation, expressway, housing and electricity are provided by "Authorities" which are public enterprises under the central government.

The central government is taking an important role in services by Bangkok Metropolis in terms of activities as well as financing.

16.2 ORGANIZATION OF DEPARTMENT OF DRAINAGE AND SEWERAGE (DDS)

The Bureau of Drainage and Sewerage (BDS) was established in 1977 as a body separated from the Bureau of Sanitation. Because of increasing problems of flooding and waste water in the canals, BDS was established to be charged with the direct responsibility for storm drainage, flood protection and sewage disposal. BDS changed its name to the Department of Drainage and Sewerage (DDS) in 1981 and then established a policy reinforcing its administrative powers. The number of officials at DDS is about 500, and it employs about 1,500 regular workers at present. (Fig. 16.1)

16.3 COORDINATION OF THE PROJECT

There are the following four flood controlling projects in neighboring regions;

(1) Bangkok Flood Control and Drainage Project (City Core)

(2) Green Belt Project

(3) Flood Control of Western Suburbs of Bangkok (Thomburi)

(4) Flood Control in Samut Prakan Province

Since flood controlling in one area may affect a flood condition of the other areas, coordination between authorities and the project teams concerned is quite important. The project has also direct linkages with; land subsidence for ground elevation; city planning for future land use; civil works for road construction. Furthermore, the project has to be ultimately given a full concensus by the residents in their districts.

A BMA Directive Committee was established for this project to have the opportunity of meeting and discussion with concerned offices from the central government, research institutions and BMA. (Fig. 16.2)

In case of a flood control project in Japan, three kinds of committees are usually established for the purpose of coordination. These committees are directive committee, advisory committee and working committee. Each committee consists of representatives from central government, prefectural or metropolitan government and district offices. A directive committee is formed with top officials, an advisory committee is formed with officials of director level and a working committee is formed with officials of chief-of-section level. (Table 16.1)

BMA Directive Committee, and an Advisory Committee are expected to have the function of coordination between various government offices.

It is recommended to set up a link with district offices in order to communicate with the residents of the flood prone areas. The Study Area covers six districts as follows: (Fig. 16.3)

(1) HUAIKWANG
(2) PHRAKHANONG
(3) BANGKHEN
(4) BANGKAPI
(5) MINBURI
(6) LAT KRABANG

16.4 PROJECT TEAM WITHIN DDS

At present, the counterpart team is the team directly working with the JICA team. In the implementation stage it is proposed that the team for this project to be set up at the same level as a division within the DDS. The formation of the team has to be considered in the later stages of the study when the details are decided.

Table 16.1 EXAMPLE OF COMMITTEES FOR FLOOD CONTROL PROJECT FOR SHINGASHI RIVER IN JAPAN

* Chairman

Participating Organization	Directive Committee	Advisory Committee	Working Committees	
			Tokyo Chapter	Saitama Chapter
Kanto Regional Construction Bureau, Ministry of Construction	*Director General of River Department	*Director of River Department Director of Planning Research Engineers(2 persons) Heads of Construction Offices(2 persons)	Chief of Planning Section Chief of River Planning Chief of Urban Survey Heads of Construction Offices(2 persons)	
Tokyo Metropolitan Government	Deputy Governor	Director of Construction Bureau Director of City Planning Bureau Director of Housing Bureau Director of Sewerage Bureau	*Chief of River Planning Chief of Facility Plann-ing Chief of House Planning Chief of Sewerage Plann-ing	-
District Offices	Heads of 13 districts and cities concerned	Directors of Department in charge of four representa-tive districts	Directors of Department in charge of 13 districts	-
Saitama Prefectural Government	Deputy Governor	Director of Civil Works Dept. Director of Planning Dept. Director of Housing Dept. Director of Agriculture Dept.	-	*Chief of River Works Chief of Planning & Coordination Chief of City Planning Chief of Agricultural Policy
District Offices	Heads of 13 cities concerned	Director of Department in charge of four representa-tive districts	-	Directors of Department in charge of 13 districts

Source : Kanto Regional Construction Bureau, Ministry of Construction

16.5 OPERATION AND MANAGEMENT PLAN

After the completion of the project, operation and management of the facilities have to be systematically made for maximum benefit to the project.

At present, DDS takes care of the maintenance of embankments, klongs, drains, gates, cofferdams, pumping stations and temporary pumps. However, there are the following major problems on aspects of the operation and management of the flood protection system.

1) Since the major gates at main klongs are under the control of the RID, coordinated operation of all pumps and gates at the time of a flood is not easily obtained.

2) Because of inadequate pumping capacity and the lack of coordinated operation of pumps at various locations, the pumped-out water sometimes worsens the flooding in neighboring areas.

In order to mitigate these problems, operations and management should be made systematically under a central flood control system with the following functions.

1) Simultaneous observation of rainfall, water level gauging of outer and inner waters at klongs, gates and pumping stations.

2) Coordinated operation and management of all pumps and gates in the area.

3) Instant communication between the central operation center and the rainfall/water stage observation stations. For this purpose the establishment of the telemetering system is indispensable.

4) Systematic flood prediction should be made at the central opeation center based on data collected from the site by means of computer.

5) Predicted flood forecast should be given timely to the public by the established flood warning system.

6) The fighting of floods when they occur should be immediate. For this purpose, the preparation of mobile pumps, equipment, machinery and tools including provisional portable pumps and the training of staff and labor are needed as routine work.

Besides the matters for flood protection, the following items should be considered for the operation and management of the facilities.

Water Pollution

Water in the klongs has to be flushed periodically by the use of gates and pumps, in order to prevent the worsening of pollution caused by waste water.

Navigation

Canal boats are still a vital means of transportation for the residents of Bangkok. The inner water has to be kept at certain level for navigation.

Irrigation

During the dry season, the water level in the retarding area is expected to be lower than the present level as the result of this, and also the Green Belt Projects. Consideration should be given to ensure sufficient irrigation water supply for agricultural land in the retarding area.

16.6 CONCLUSION

As the conclusion the following points are important.

1) Organization frame work with the function of coordination between different government authorities.

2) Establishing committees to communicate with residents in the flood-prone areas.

3) Establishment of a project team within the DDS with the special function of implementing the project.

4) Forming a central control system for flood control and flood forecasting and warning system by consolidating the operation of drainage facilities and observation of rainfall and water level in the area.

5) Operation of drainage facilities should be considered with the environmental problems, transportation and irrigation function of the klongs.

Chapter 17 FINANCE

In this chapter, the method of financing the project cost is studied and proposed. A rough calculation of cost was attempted in order to present a sample study under several hypotheses.

17.1 REVENUE AND EXPENDITURE OF BMA AND DDS

Financial sources of BMA are various municipal taxes, fees and income of BMA, transfer of tax collected by the central government (shared tax) and special subsidy. The revenue funded by the central government, shared tax and subsidy, accounts for about 35% of the total. The total revenue, ฿ 4,526 million in 1983, is an increase of 4.2% from 1982, while it was 10% increase in the previous year. (Table 17.1)

The budget of DDS indicates a sharp increase during these three years mainly due to increased awareness for flood protection. The 1983 budget is approximately 381 million Baht (38% increase from 1982). About 137 (36%) million Baht is for flood protection, 152 million Baht (40%) is for sewerage and 75 million Baht is for canal maintenance. (Fig. 17.1)

17.2 FINANCIAL PLAN

At this stage of study, a detailed cost estimates cannot be obtained since the facilities to be constructed are not yet defined. However, if there is past experience on cost estimate on similar type of project, an approximate cost is able to be obtained. In this regard, a cost estimate of the core flood protection project can be used to obtain the assumed unit cost calculated as follows.

The cost estimates for pumping stations and klong improvement of city core project are:

	(฿ million)
Pumping Station	900.9
Klong Improvement	436.7
Total*	1,337.6

Source: Bangkok Flood Control and Drainage Project (City Core) General Study Report (DRAFT) September 1983 BFCD Joint Venture

* : Costs for land aquisition and flood protection barrier are excluded for this estimate. (Refer to section 7.2)

Table 17.1 BMA ANNUAL REVENUE AND EXPENDITURE

	(Revenue)	1981 ฿ mill	1981 %	1982 ฿ mill	1982 %	1983 ฿ mill	1983 %
1.	Local Taxes	500	12.6	568	13.1	657	14.5
	(House & Rent Taxes)	(403)	(10.2)	(425)	(9.8)	(500)	(11.0)
	(Land Development)	(54)	(1.4)	(95)	(2.2)	(110)	(2.4)
2.	Surcharge Taxes	1,439	36.4	1,656	38.1	1,832	40.4
3.	Shared Taxes	724	18.3	637	14.7	657	14.5
4.	Fee for Licensing and Permits	81	2.3	99	2.3	100	2.2
5.	Commercial Income	218	5.5	183	4.2	183	4.0
6.	Miscellaneous Income	209	5.3	208	4.8	206	4.5
7.	Subsidy	782	19.8	989	22.7	891	19.7
	Total Revenue	3,953		4,340		4,526	

	(Expenditure)	1981 ฿ mill	1981 %	1982 ฿ mill	1982 %	1983 ฿ mill	1983 %
1.	Public Work	900	22.7	952	22.2	895	19.2
2.	Education	859	21.7	912	21.3	885	19.0
3.	General Administration	529	13.3	519	12.1	633	13.6
4.	Medicine and Sanitation	387	9.7	394	9.2	484	10.4
5.	Cleaning	346	8.7	308	7.2	618	13.3
6.	Drainage System	147	3.7	277	4.5	381	8.2
7.	Social Welfare	146	3.6	117	2.7	122	2.6
8.	Commerce	60	1.5	55	1.3	115	2.4
9.	Loan Repayment	8	0.2	7	0.2	4	0.07
10.	Project funded by Central Government	574	14.5	738	17.2	504	10.8
	Total Expenditure	3,956		4,281		4,641	

Note – The figures of revenue and expenditure in 1982, 1983 are estimated by BMA.

Source: BMA documents

Table 17.2 REVENUE & EXPENDITURE OF TOKYO METROPOLIS 1983

Revenue	¥ million	%
1. Municipal Taxes	2,456,049	71.6
(Resident tax)	(812,799)	(23.7)
(Business tax)	(731,006)	(21.3)
(Property tax)	(410,651)	(12.0)
(City Planning tax)	(117,179)	(3.4)
2. Fees	101,255	3.0
3. Incomes	199,403	5.8
4. Subsidy	378,834	11.0
5. Bond	192,400	5.6
6. Others	102,059	3.0
Total	3,430,000	100.0
Expenditure		
1. General Administration	192,557	5.6
2. City Planning & Environment	59,446	1.7
3. Social Welfare	220,428	6.4
4. Industrial & Commerce Promotion	145,308	4.2
5. Housing	190,526	5.6
6. Medical & Sanitation	63,698	1.9
7. Garbage Collection	153,267	4.5
8. Public Works	208,421	6.1
9. Drainage High Tide Protection	59,248	1.7
10. Education	721,089	21.0
11. Police & Fire Protection	483,775	14.1
12. Bond	274,286	8.0
13. Subsidy for Sewerage Operation	132,295	3.9
14. Other subsidies	523,956	15.3
Total	3,430,000	100.0

Source : Budget for Fisical Year 1983, Tokyo Metropolis

The unit cost is:

฿ 1,337.6 million ÷ 86 km^2 = ฿ 16 million/km^2

For rough estimation, five cases of area to be covered are considered. (Refer to section 15.2)

Case 1	501 km^2 x ฿ 16 million =	฿ 8,016 million	
Case 2	370 km^2 x ฿ 16 million =	฿ 5,920 million	
Case 3	260 km^2 x ฿ 16 million =	฿ 4,160 million	(for proposed Master Plan Area)
Case 4	200 km^2 x ฿ 16 million =	฿ 3,200 million	
Case 5	170 km^2 x ฿ 16 million =	฿ 2,720 million	

It is assumed that 50% of the construction cost is foreign currency portion and 50% is local currency portion which will be subsidized by the central government as is the case for core project. The construction is assumed to take 5 years and the foreign loan (3.5% interest) is to be paid back in 25 years with the grace period of 5 years. This condition roughly follows the Japanese aid loan. The cost recovery, repayment of the loan, is assumed to be paid by the BMA, since this has been suggested by the NESDB and the Ministry of Finance. The annual operating cost is calculated at 3% of construction cost referring the core project.

The result is shown on Table 17.3 and Fig. 17.3. On Fig. 17.3, the annual cost for the BMA can be compared with the total budget of the DDS in 1983. For the proposed area of Master Plan, average annual cost for the BMA after the 5th year is ฿ 267 million which is about 70% of the DDS budget in 1983, and about two times of the flood protection budget of the DDS. Although there has been a sharp increase of the DDS budget in recent years, financing the required cost might not be easy, since the DDS has to take care of the city core and other areas as well. Under limited financial resources, additional source of financing and determination on priority of the area to be protected have to be carefully considered.

17.3 SOURCE OF FINANCING

The estiamted cost means a substantial burden to the BMA. NESDB is suggesting that a system to collect the cost from people who get benefit from this project should be considered as the primary source of financing.

The people who get benefit from this Project done by RID with a World Bank loan property in the area, commuters who suffer from traffic problems.

In the case of Chao Phraya II Irrigation Project done by RID with a World Bank loan in 1976, collecting fees from beneficiaries (farmers) was adopted to cover 12 – 15% of the total project cost. The rate was ฿ 690/ha per year for the period of 15 years which is the term of loan repayment.

Table 17.3 CASH FLOW SCHEDULE UNDER ASSUMPTION

(฿ million/year)

Case	Project Cost		Year 1-5	Year 6-15	Year 16-25	Total
Case - 1 ($501\ km^2$)	Local Construction Cost	Subsidy	401			2005
		B M A	401			2005*
		Total	802			4010
	Foreign Construction Cost	Disbursement	802			4010
		Repayment	-	200	200	4010
		Interest	0 - 112	140 - 77	70 - 7	1614
		Total	0 - 112	340 - 277	270 - 207	5624*
	Operating Cost		0 - 192	240	240	5280*
	Total BMA Payment		401 - 705	580 - 517	510 - 447	12909
Case - 2 ($370\ km^2$)	Local Construction Cost	Subsidy	296			1480
		B M A	296			1480*
		Total	592			2960
	Foreign Construction Cost	Disbursement	592			2960
		Repayment	-	148	148	2960
		Interest	0 - 83	104 - 57	52 - 5	1191
		Total	0 - 83	352 - 205	200 - 153	4151*
	Operationg Cost		0 - 142	178	178	3916
	Total BMA Payment		296 - 521	333 - 308	305 - 280	9547
Case - 3 ($260\ km^2$)	Local Construction Cost	Subsidy	208			1040
		B M A	208			1040*
		Total	416			2080
	Foreign Construction Cost	Disbursement	416			2080
		Repayment	-	104	104	2080
		Interest	0 - 58	73 - 40	36 - 4	638
		Total	0 - 58	177 - 144	140 - 108	2918*
	Operating Cost		0 - 100	125	125	2750*
	Total BMA Payment		208 - 366	302 - 269	265 - 233	6708
Case - 4 ($200\ km^2$)	Local Construction Cost	Subsidy	160			800
		B M A	160			800*
		Total	320			1600
	Foreign Construction Cost	Disbursement	320			1600
		Repayment	-	80	80	1600
		Interest	0 - 45	56 - 31	28 - 3	694
		Total	0 - 45	56 - 111	108 - 83	2244*
	Operating Cost		0 - 77	96	96	2112*
	Total BMA Payment		160 - 301	152 - 207	204 - 179	5156
Case - 5 ($170\ km^2$)	Local Construction Cost	Subsidy	136			680
		B M A	136			680*
		Total	272			1360
	Foreign Construction Cost	Disbursement	272			1360
		Repayment	-	68	68	1360
		Interest	0 - 38	48 - 26	24 - 2	548
		Total	0 - 38	116 - 94	92 - 70	1908*
	Operating Cost		0 - 65	82	82	1803*
	Total BMA Payment		136 - 239	198 - 176	174 - 152	4391

Interest rate of foreign loan : 3.5%
* Cost accrues to BMA in total

The Ministry of Finance is now considering levying a tax on a land owner in the city core area to partially finance the project. The owner of land is a beneficiary from the flood protection project. According to the core project study, the value of the land indicates an 18% difference between a flood prone area and a non-flooded area.

In the BMA financial resources, the tax levied on land, and land development tax, is about 2.2% in 1983. In the case of Tokyo Metropolis for example, property tax on land and building is 12% of revenue and there is another 3% of urban development tax which is specially used for developing urban infrastricture in metropolitan area. Thus a total of 15% of Tokyo's revenue is based on property valuation. This is based on the idea that as urban infrastructural facilities develops, the value of land also increases. (Fig. 17.2)

While increasing the tax from land owners is one possible source of financing, another possible source is collecting a fee from residents. The sewerage in Tokyo Metropolis is operated/managed by the Sewerage Authority of Tokyo Metropolis (public enterprise), which has its revenue collected from residents. In the 1983 budget, the fee revenue is ¥112 billion which accounts for ¥10,000 (฿1,000) per resident per year. The total budget of the Sewerage Auhthority is ¥584 billion, consisting of ¥132 billion of subsidy from Tokyo Metropolis, ¥112 billion from the fees collected and other revenues. (Table 17.4) On the other hand, drainage of rivers and high tide protection in Tokyo Metropolis is undertaken directly by the Construction Bureau of Tokyo Metropolis, and its drainage budget is ¥59 billion in 1983.

If the budget for drainage and subsidy for sewerage of Tokyo Metropolis are added together, the total is about ¥191 billion, 5.6% of the total budget, which accounts for ¥16,311 (฿1,631) per resident. Thus the total burden for drainage and sewerage in Tokyo is ¥26,000 (฿2,600) per resident on average, with the addition of the ¥10,000 sewerage fee.

The 1983 budget for drainage and sewerage in Bangkok is ฿381 million, 8% of the BMA budget, accounting for ฿67 per resident on average. These figures indicate a Tokyo resident pays 39 times as much as of a Bangkok resident. Even though taking account of average income difference between two countries, the drainage and sewerage budget per resident in Bangkok is much lower than in Tokyo, whilst the flood problem is much more serious in Bangkok. (Table 17.5)

As details of this project will be defined in later stages of the study, a cost estimate will also be obtained. However, at this stage, the financing of local costs and repayment of the foreign loan have to be carefully planned along with the source of fund and size of the project.

Table 17.4 REVENUE AND EXPENDITURE OF SEWERAGE AUTHORITY, TOKYO METROPOLIS, 1983

Operational Account	(¥ million)
Revenue	
Sewerage Fee	111,504
Subsidy	96,141*
Other Revenue	18,347
Special Revenue	4,188
Total	230,180
Expenditure	
Salaries	12,560
Operation & Maintenance	58,116
Depreciation	32,578
Interest payment	110,173
Others	852
Total	214,279
Balance	15,901
Expenditure Without Cash Payment	33,258
Cash Balance	49,159

Development Account	
Revenue	
Bond	200,659
Subsidiary from Tokyo Metropolis	31,714*
Subsidy from Central Govt.	71,356
Others	20,790
Total	324,519
Expenditure	
Construction	286,311
Bond Repayment	73,544
Others	10,143
Total	369,988
Balance	- 45,479
Cash Balance from Operation Account	49,159
Total Balance	3,680

* Besides these items, ¥4,440 million is subsidized by Tokyo Metropolis in "Other Revenue" thus, the Total of Subsidy from Tokyo Metropolis is : ¥ 132,295 million

Table 17.5 COMPARISON OF DRAINAGE AND SEWERAGE BUDGET BETWEEN BMA AND TOKYO METROPOLIS

	BMA	Tokyo
Drainage		
Total	฿ 217,158,000 1)	¥ 59,248 million
Per Head	฿ 38	¥ 5,045
Sewerage		
Total	฿ 164,138,000 2)	¥132,295 million 3) (¥584,277 million)4)
Per Head	฿ 29	¥ 11,266 (¥ 49,755)
Total		
Total	฿ 381,297,000	¥643,525
Per Head	฿ 67	¥ 16,311 3) (¥ 54,800)4)

1) Total of budget for Canal Maintenance Division, Flood Protection budget and proportional budget for Technical Division and Secretary.

2) Total of budget for Drainage Control Division, Water Treatment Division and proportional budget for Technical Division and Secretary.

3) The figure is subsidy from Tokyo Metropolis.

4) The figure is total budget of Sewerage Authority, consisting of various sources including subsidies and collected fees.

17.4 CONCLUSION

There are two important matters for consideration:

1) Since the project cost is expected to be a substantial amount, finding new financial sources from people who benefit from this project should be considered.

2) Setting of priorities within the Master Plan Area should be done to identify stage constructions under the expected financial constraints.

Chapter 18 CONCLUSIONS & RECOMMENDATIONS

18.1 GENERAL

This Study focussed on setting up strategies for the flood protection and drainage of 501 km^2 area in Eastern Bangkok. The Study Team has conducted the Preliminary Study on the flood protection/drainage system, organizational, operational and managerial aspects of the project, based on general concepts for flood protection measures.

The Study Team concluded that an area of 260 km^2 is to be protected from flood while the rest, unurbanized area, is to be reserved as a retarding area. The identified flood protection area (260 km^2) is to be the area for the Master Plan for realization of flood protection/drainage in Eastern-Suburban Bangkok.

18.2 CHARACTERISTICS OF THE STUDY AREA

The Study Area is located in the deltaic alluvial plain of the Chao Phraya basin which is characterized by the extremely low-lying and flat ground surface, rapidly increasing urbanization by the increase of population and land subsidence caused by the withdrawal of groundwater.

The Chao Phraya basin is covered by intersecting klongs which are mainly used for the supply of irrigation water and for navigation. In rainy season, however, a large amount of water flows into the Study Area through the klongs from outer areas. In the case of the 1980 flood, more than a half the amount of the stored storm-water in the Study Area was inflow from the outer areas, according to calculations by the Study Team.

The eastern half of the Study Area is not yet urbanized and remains as paddy field with a large capacity for storm-water storage which is contributing to the decrease of substantial water discharge into the Master Plan Area.

18.3 FLOOD PROTECTION/DRAINAGE SYSTEM

Major causes of flood and flood damage in the Study Area are summarized as;

1) Heavy rainfall
2) Low flat plain and high water level of the Chao Phraya River
3) Inflow of water from outer area
4) Progression of land subsidence

5) Insufficient drainage capacity
6) Change in land use conditions

The basic concept of the flood protection/drainage system consists of the establishment of flood plain management and structural measures.

The following measures are considered for flood plain management:

1) Identification and Publicizing of Flood-Prone Area
2) Land Use Regulations
3) Encouragement of Individual Flood-Proofing Measures
4) Emergency Flood Fighting and Flood Warning Systems
5) Flood Protection Committee

The followings are key items for structural measures;

1) Prevention of land subsidence
2) Prevention of inflow from outer areas (Green Belt Project)
3) Prevention of inflow from the Chao Phraya River
4) Conservation of retarding area
5) Improvement of drainage capacity in protection area

Based on this concept, the methodology for the Study on flood protection/drainage system was prepared. According to the methodology, the rough study on the flood protection/drainage system was made.

Firstly, the impact of the Green Belt Project was proved to be very effective for the project.

Secondly, the impact of the retarding area in the eastern part was identified as useful.

Thirdly, one idea of the flood protection/drainage system was studied/depicted for reference to the Master Plan Study.

Incidentally the "Committee of Flood Protection and Solution in BMA and the Circumference" established on the occasion of an occurrence of extraordinary rainfall and flood in 1983 is now planning and executing the urgent measures which aim at the prevention of inflow from the outer areas and quick discharge of storm-water from the left bank of the River, including the Study Area. These concepts are considered to be consistent with the concepts of the Study Team.

18.4 MASTER PLAN AREA

Based on the established criteria for the selection of the Master Plan Area, the Study Team selected the area of low and medium density populated area in the year 2000 covering an area of 260 km² by studying on the need for future urbanized areas, flood damage, hydrological and physical boundaries and economic conditions.

18.5 ORGANIZATION, OPERATION AND MANAGEMENT PLAN

For the successful execution of the Project, the organization, operation and management plan plays a very important role. Some recommendations are presented for the plan and especially the establishment of a central control and management system is emphasized.

18.6 SUGGESTION FOR MASTER PLAN STUDY

Based on the established basic flood protection and drainage system, the most appropriate system will be selected in the proposed Master Plan Area.

The following items will be studied as has been proposed in the Inception Report, May 1983.

1) Supplementary Data Collection and Analysis
2) Planning of Flood Protection and Drainage System
3) Planning of Facilities
4) Construction Material and Labor
5) Construction Program
6) Estimation of Construction Cost
7) Economic Evaluation
8) Financial Plan
9) Organization and Operation Plan
10) Development of Criteria and Selection of Feasibility Study Area